LOAD CLASSIFICATION

PSEE
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Load classification

You can classify what types of load in the system by inspection using the following types of load and corresponding type of stress.

What is stress and the relationship between the load?

Stress is the measure of an external **force** acting over the **cross sectional area** of an object. Stress has units of force per area: N/m^2 (SI) or lb/in^2 (US). The SI units are commonly referred to as Pascal's, abbreviated **Pa**. Since the 1 Pa is inconveniently small compared to the stresses most structures experience, we'll often encounter 10^3 Pa = 1 kPa (kilo Pascal), 10^6 Pa = a MPa (mega Pascal), or 10^9 Pa = GPa (giga Pascal).

The **relationship between loads** and **stress** is that you cannot have one without the other. When too much **load** is applied, it begins to **stress** a part or component. When given the exact same cross sectional areas, as the **load** increases, the **stress** will increase consequently

Different basic and most common types of loads in engineering mechanics are compression, tension, torsion and bending.

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Compression load

Compression loading is an effect in which the component reduces it size. During compression load there is reduction in volume and increase in density of a component. (https://me-mechanicalengineering.com)

Assumptions:
1. The material will increase its temperature
2. Volume will decrease (if compressible)
3. Mass is constant
4. Force projected area will increase
5. L or length will decrease

For the derivation visit the link:
https://www.youtube.com/watch?v=c6ndD5kTkP4

$$S_c = \frac{F_{net}}{A}$$

S_c = compression stress (of material)
F_{net} = net force or the force difference between F1 and F2
A = area perpendicular to the forces

F1 = F2, then the system is in equilibrium
F1 not equal to F2 then the system is not in equilibrium

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Tension load

Compression loading is an effect in which the component reduces it size. During compression load there is reduction in volume and increase in density of a component. (https://me-mechanicalengineering.com)

$$S_c = \frac{F_{net}}{A}$$

S_c = compression stress (of material)
F_{net} = net force or the force difference between F1 and F2
A = area perpendicular to the forces

Assumptions:
1. The material will increase its temperature
2. Volume will increase (if expandable)
3. Mass is the same
4. Force projected area will decrease
5. L or length will increase

F1 = F2, then the system is in equilibrium
F1 not equal to F2 then the system is not in equilibrium

For the derivation visit the link:
https://www.youtube.com/watch?v=c6ndD5kTkP4

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Torsion of solid shaft

In the field of solid mechanics, **torsion** is the twisting of an object due to an applied torque. Torsion is expressed in either the Pascal (Pa), an SI unit for newton's per square meter, or in pounds per square inch (psi) while torque is expressed in newton meters (N·m) or foot-pound force (ft·lbf). In sections perpendicular to the torque axis, the resultant shear stress in this section is perpendicular to the radius.
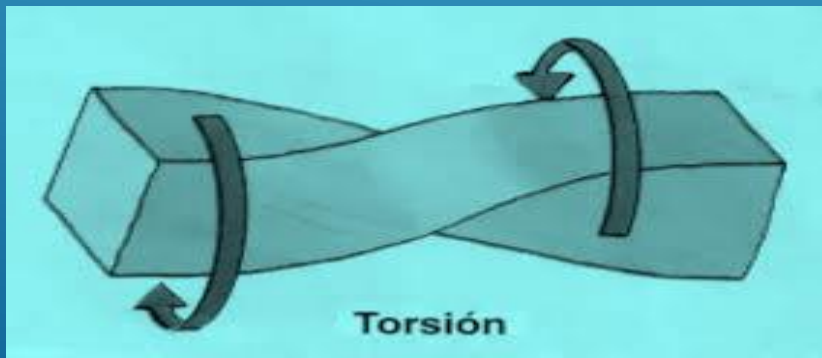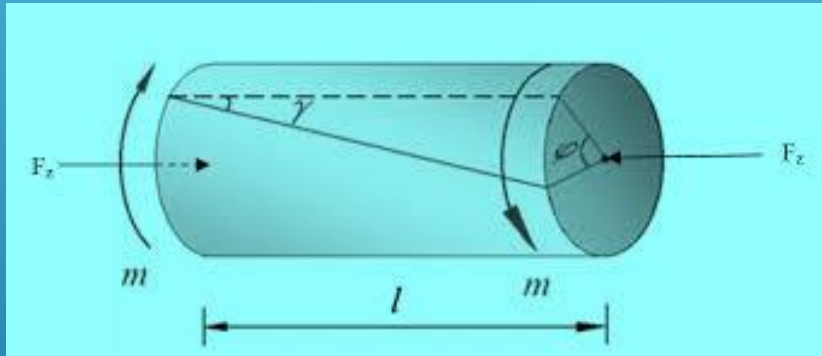
Torsión

In the development of a torsion formula for a circular shaft, the following assumptions are made:
1. Material of the shaft is homogeneous throughout the length of the shaft.
2. Shaft is straight and of uniform circular cross section over its length.
3. Torsion is constant along the length of the shaft.
4. Cross section of the shaft which are plane before torsion remain plane   after torsion.
5. Radial lines remain radial during torsion.
6. Stresses induced during torsion are within the elastic limit.

https://www.oreilly.com/library/view/strength-of-materials/9789332514829/xhtml/ch6sec2.xhtml#:~:text=In%20the%20development%20of%20a,the%20following%20assumptions%20are%20made%3A&text=Cross%20section%20of%20the%20shaft,are%20within%20the%20elastic%20limit.

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Torsion of solid shaft cont….

$$S_s = \frac{16T}{\pi D^3} = \frac{Tc}{J}$$

S_s= torsional shear stress
T = torque
J = polar moment of inertia
D = shaft diameter
c = distance from neutral axis to the farthest fiber equal to radius or r (for circular cross sectional area)

For the derivation visit the link:
https://www.youtube.com/watch?v=c6ndD5kTkP4

For the derivation visit the link:
https://www.youtube.com/watch?v=8GYn84yi6bQ

Definition Reminders:

TORSIONAL STRESS Shear **stress** produced when we apply the twisting moment to the end of a shaft about its axis is known as **Torsional stress**.
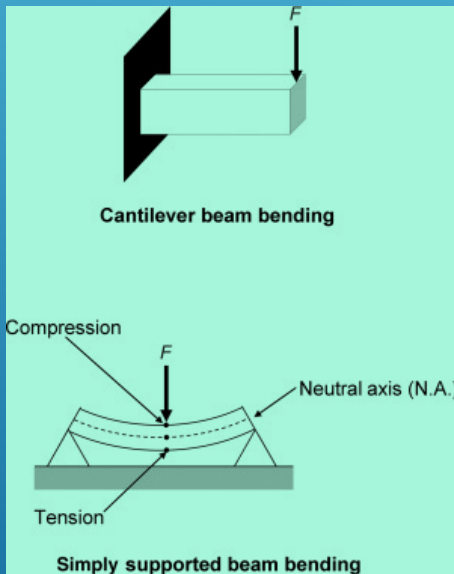**Torsion** is the twisting of an object due to an applied torque
Torque, moment, moment of force, rotational force or "turning effect" is the rotational equivalent of linear force. The concept originated with the studies by Archimedes of the usage of levers. Just as a linear force is a push or a pull, a torque can be thought of as a twist to an object around a specific axis.
The **polar moment of inertia**, also known as second **polar moment** of area, is a quantity used to describe resistance to torsional deformation (deflection), in cylindrical objects (or segments of cylindrical object) with an invariant cross-section and no significant warping or out-of-plane deformation.

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Bending load

Bending stress is a more specific type of normal **stress**. When a beam experiences load like that shown in figure one the top fibers of the beam undergo a normal compressive **stress**. The **stress** at the horizontal plane of the neutral is zero. The bottom fibers of the beam undergo a normal tensile **stress**.

Bending Moment

Force distribution within beam

Cantilever beam bending

Compression

Neutral axis (N.A.)

Tension

Simply supported beam bending

$$S_b = \frac{My}{I_x}$$

S_b = bending stress, Pa
M = Moment accumulated within the neutral axis, N.m
y = Perpendicular distance to the neutral axis, m
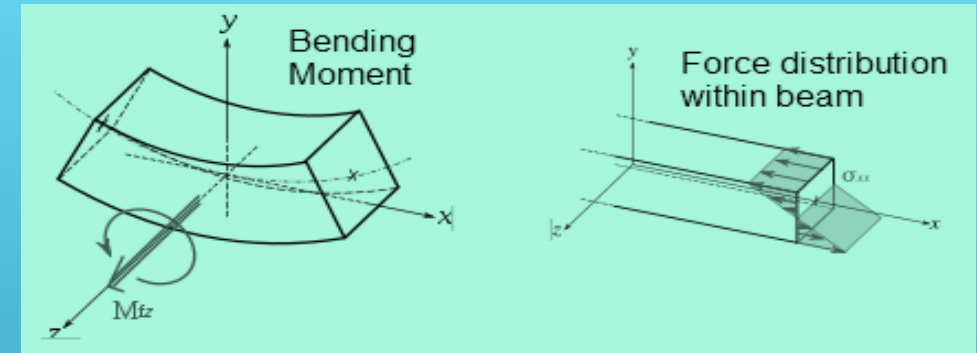I_x = Second moment area of neutral axis, m^4

For the derivation visit the link:
https://www.youtube.com/watch?v=c6ndD5kTk
P4

Table 1. Typical Equations to Calculate Bending Moment

Shape of Beam	Bending Moment M
W, L	$M = WL$
$\frac{\ell}{2}$ W $\frac{\ell}{2}$, L	$0 \le L \le \frac{\ell}{2} \longrightarrow M = \frac{W\ell}{2}\left(\frac{1}{4} - \frac{L}{\ell}\right)$ $L = 0 \quad L = \frac{\ell}{2} \longrightarrow M = \pm \frac{W\ell}{8}$ $\frac{\ell}{2} \le L \le \ell \longrightarrow M = \frac{W\ell}{2}\left(\frac{L}{\ell} - \frac{3}{4}\right)$
$\frac{\ell}{2}$ W $\frac{\ell}{2}$, L	$0 \le L \le \frac{\ell}{2} \longrightarrow M = -\frac{WL}{2}$ $L = \frac{\ell}{2} \longrightarrow M = -\frac{W\ell}{4}$ $\frac{\ell}{2} \le L \le \ell \longrightarrow M = -\frac{W(\ell - L)}{2}$
W ℓ_1 ℓ_2 ℓ_1 W, L	$0 \le L \le \ell_1 \longrightarrow M = WL$ $\ell_1 \le L \le (\ell_1 + \ell_2) \longrightarrow M = W\ell_1$

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